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Comparative Study of Virtual Sickness between a Single-screen and Three-screen from Parallax Affect

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***Abstract*—**Virtual environment induces simulator sickness effect for some users. The purpose of this research is to compare the simulation sickness relative with parallax affect in one-screen and three-screen HoloStage^{TM} system, measured by Simulation Sickness Questionnaire (SSQ). The results show the subjects tested in three-screen has less sickness than one-screen and effect from the Oculomotor (O) more than from the Disorientation (D) and more than from the Nausea (N) or represented in O>D>N.

***Keywords*—**Virtual environment, virtual sickness, simulation sickness questionnaire, HoloStage^{TM}.

I. Introduction

VIRTUAL REALITY or virtual environments have become currently substantial and ubiquitous technology in several fields as entertainment purpose, training, medicine, architecture and telepresence.

Although this new technology is wildly used, some users indicate symptom from virtual environment. There are amount of simulator sickness reported in [1]-[2] in virtual army training, and also for wide range research of simulator sickness [3-6].

Groups of research proposed the simulator sickness from eye gazing by adjusted the scene [7-9] or intensity [10]. This research concludes the difference between one-screen and three-screen in HoloStage^{TM} system when the scene is in different parallax.

II. Methods

A. Experiment

The experiment has been done with HoloStage^{TM} system [11] as shown in Fig. 1. The HoloStage^{TM} has three sides of 2×4, 2×2, and 2×4 meters for front side, right side and bottom side, respectively. The system consists of five stereoscopic channels eye-tracked projection system powered by the VR4MAX extreme multi-channel rendering software.

Fig. 1 HoloStage^{TM} system in Tokai University

Because the main purpose of this experiment is to study about the simulation sickness affected by different parallax by using VR4MAX software to set the parallax for distance between eyes in the scene period. The distance between eyes is set to 2.0 centimeters (cm) for less parallax and 6.5 cm which is normal distance between eyes for normal parallax for one-screen and three-screen HoloStage^{TM} system.

Since this test should be done under the same condition of animation then control same animation walk for every subject, the city-walkthrough simulation is used. The walkthrough in scene as shown in Fig.2 includes random turn left; turn right and cross the bridge with no severe but perceived action for every experiment for two minutes period of time.

B. Subjects

Twenty-three healthy subjects participated in the study. The entire subjects are Japanese student in Tokai University and all of them have experienced in HoloStage^{TM} system. The gender of subjects is irrelevant referred to [12] reported that virtual environment creates the similar effect on both male and female person. The subject divided into 4 groups of testing;

1) One-screen HoloStage^{TM} system with 2.0 cm parallax; 6 subjects (5 Male persons and 1 female person) age between 21-28 years with age average of 23.67.
2) Three-screen HoloStage^{TM} system with 2.0 cm parallax; 5 subjects (4 Male persons and 1 female person) age between

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22-24 years with age average of 22.80.

3) One-screen HoloStage[TM] system with 6.5 cm parallax; 6 subjects (5 Male persons and 1 female person) age between 21-26 years with age average of 22.83.
4) Three-screen HoloStage[TM] system with 6.5 cm parallax; 6 subjects (6 Male persons) age between 22-25 years with age average of 23.33.

One subject group is tested for only one experiment in order to avoid familiarity of the scene due to repeated exposure as suggested in [13].

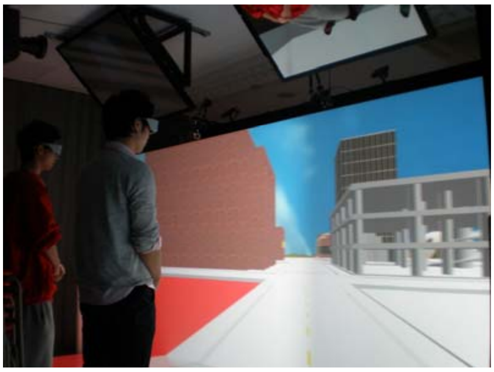

Fig. 2 Scene experiment

III. Results

A. Analysis in mean degree of symptom

The results are evaluated by the famous Simulation Sickness Questionnaire (SSQ) [14-17] for post experiments. The SSQ consist of question for 16 symptoms; general discomfort, fatigue, headache, eyestrain, difficulty focusing, increased salivation, sweating, nausea, difficulty concentrating, fullness of head, blurred vision, dizzy (eyes open), dizzy (eye closed), vertigo, stomach awareness and burping. The choices for each question are none (0), slightly (1), moderate (2) and severe (3) as feeling level in each symptom. The percentage in mean of each degree of symptom is shown in Fig. 3.

For overall 16 SSQ questions, most subjects respond no effect answer (or 0) as 75.00%, 89.06%, 83.33% and 92.77% represent to group 1, group 2, group 3 and group 4, respectively.

The experiment reports symptom in slightly feeling (or 1) as 19.79%, 10.94%, 14.58% and 6.02% and in moderate (2) as 5.21%, 0.00%, 2.08% and 1.20% in order of group 1, group 2, group 3 and group 4, respectively.

Nobody responds for severe symptom (or 3) in SSQ.

B. Analysis in sixteen questions

Mean (μ) and Standard Deviation (SD) by weighting with number of subjects in each group of sixteen equations are shown in Fig. 4. Three highest-means for the one-screen system with 2.0 cm parallax comes from general discomfort and fatigue (μ = 0.83), fullness of head (μ = 0.67) and difficulty concentration (μ = 0.50). While reporting no symptom for headache, increased salivation, sweating and burping.

Three highest-means for the three-screen system with 2.0 cm parallax are from eyestrain (μ = 1.00), general discomfort and headache (μ = 0.80) and fullness of head (μ = 0.60). While reporting no symptom for vertigo, stomach awareness and burping.

Three highest-means for the one-screen system with 6.5 cm parallax are from general discomfort (μ = 0.83), eyestrain (μ = 0.50) and vertigo (μ = 0.33). While reporting no symptom for headache, sweating, blurred vision, dizzy (eyes closed) and burping.

Three highest-means for the three-screen system with 6.5 cm parallax comes from fatigue and eyestrain (μ = 0.67), general discomfort and difficulty concentrating (μ = 0.50) and difficulty focusing (μ = 0.33). While reporting no symptom for sweating, nausea, dizzy (eye open), stomach awareness and burping.

However, Fig.4 shows graph in high mean is high standard deviation that indicate the data is spread out over a wide range of values or just few subjects have prestige severe feeling.

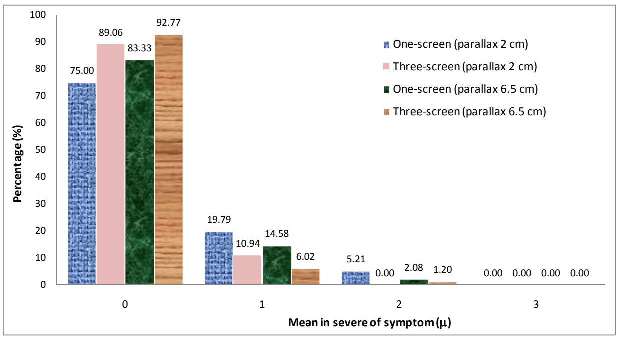

Fig. 3 The mean of each degree of SSQ symptom (0, 1, 2, 3; none, slightly, moderate, severe feeling)

C. Analysis in Oculomotor, Disorientation and Nausea

Group the symptoms from the questionnaire to three distinct symptom clusters [14], to group the symptom headache, eyestrain, difficulty focusing and blurred vision as *Oculomotor* (O), symptom dizzy (eye open), dizzy (eye closed) and vertigo as *Disorientation* (D), and symptom increased salivation, nausea, stomach awareness and burping as *Nausea* (N). The average score of three distinct symptom clusters is shown in Figure 5.

The most effect for the mean of degree of symptom for one-screen system with 2.0 cm parallax is oculomotor (μ = 0.25), more than disorientation (μ = 0.17) and more than nausea (μ = 0.13) or (O>D>N).

The most effect for the mean of degree of symptom for three-screen system with 2.0 cm parallax is oculomotor (μ = 0.60) that outstanding highest, more than disorientation (μ = 0.20) and more than nausea (μ = 0.15) or (O>D>N).

The most effect for the mean of degree of symptom for one-screen system with 6.5 cm parallax is oculomotor and disorientation (μ = 0.17) and more than nausea (μ = 0.13) or ((O=D)>N).

The most effect for the mean of degree of symptom for

Three-screen system with 6.5 cm parallax is oculomotor (μ = 0.33), more than disorientation (μ = 0.11) and more than nausea (μ = 0.04) or (O>D>N).

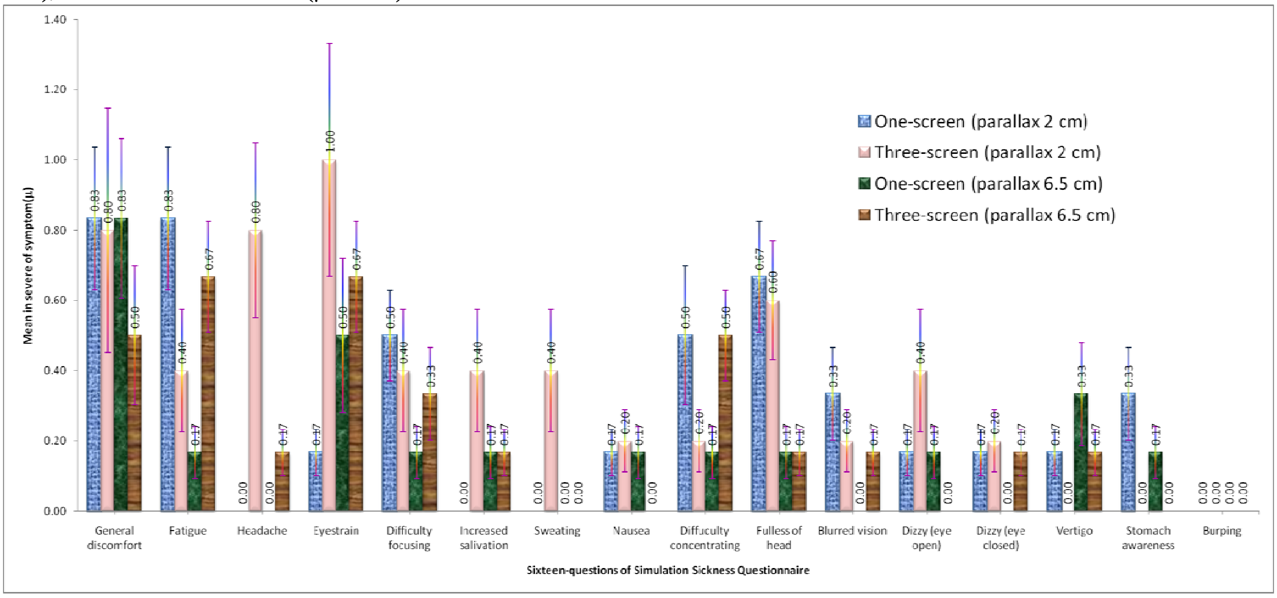

Fig. 4 Mean of sixteen questions for four-group experiments

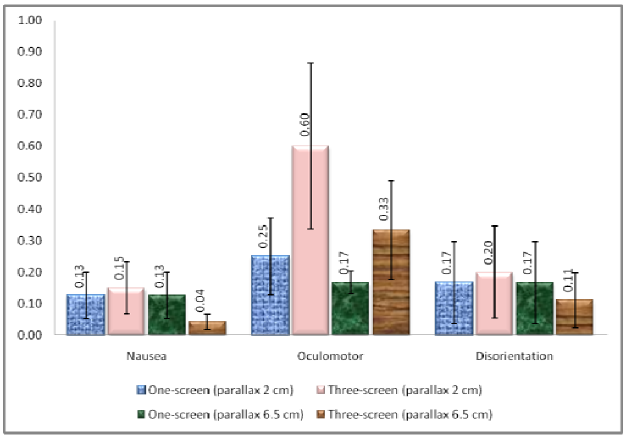

Fig. 5 The comparative results between three distinct symptom clusters

IV. Discussion

The hypothesis of parallax affect in this research is the least parallax to make image nearly feeling 2D should be less sickness affected for the user. Then, the study between 6.5 cm parallax as normal distance between human two-eyes and 2.0 cm as least parallax are set to compare.

The results obviously contradict from hypothesis. The mean comparison in degree of sickness from Fig. 3 shows that three-screen system is less sickness affected than one-screen system and parallax 6.5 cm is less sickness affected than parallax 2.0 cm, and no subject reported to severe feeling sickness. However, for the oculomotor case, three screen system affected to sickness more than one-screen system. This result harmoniously with increasing screen space increasing productivity [18] then effect from "seeing" is increasing.

Considering in each SSQ question, the top-three highest report is in consecutively; eyestrain, general discomfort and fatigue. The subject responds sweating in only three-screen with
2.0 cm parallax case, also with highest score for eyestrain. None of subjects report for burping.

The most effect to subjects comes from oculomotor, and are more than the disorientation and more than the nausea (*O* > *D* > *N*). As the tested subject in three-screen with 2.0 cm parallax is explicit effect in the study. From the experiment observation, some question from SSQ can be reduced, such as "burping" question.

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